ARCADIS

Infrastructure · Water · Environment · Buildings

Imagine the result

Liberty Dairy and H&S Bosma Dairy

Quality Assurance Project Plan

Lagoon Evaluation

Administrative Order on Consent

SDWA-10-2013-0080

October 2, 2013

ARCADIS
Infrastructure · Water · Environment · Buildings

Imagine the result

Quality Assurance Project Plan

Lagoon Evaluation

Liberty Dairy and H&S Bosma Dairy

Administrative Order on Consent SDWA-10-2013-0080

Yakima, Washington

Plan Approvals:

Kevin M. Freeman, PG
Project Coordinator

Steve Hicks, PE
Quality Manager

Quality Assurance Project Plan

Lagoon Evaluation

Prepared for:
Liberty Dairy LLC

Prepared by:
ARCADIS U.S., Inc.
695 North Legacy Ridge Drive
Suite 200
Liberty Lake
Washington 99019
Tel 509 928 3369
Fax 509 928 3075

Our Ref.:
SK030326.0001

Date:
October 2, 2013

Figures

Appendices

Acronyms and Abbreviations

AOC	Administrative Order on Consent
DQO	data quality objective
EPA	U.S. Environmental Protection Agency
HSP	Health and Safety Plan
MCL	maximum contaminant level
PARCC	precision, accuracy, representativeness, comparability, and completeness
PC	Project Coordinator
QAM	Quality Assurance Manager
QAPP	Quality Assurance Project Plan
QC	quality control
RO	reverse osmosis
SOP	standard operating procedure
SOW	Statement of Work
SSC/STL	Site Safety Coordinator/Sampling Team Leader

Distribution List (A3)

Henry Bosma	Liberty Dairy and H&S Bosma Dairy
Eric Winiecki	EPA
Gina Greppo-Grove	EPA
Rene Fuentes	EPA
Jennifer MacDonald	EPA
Kevin Freeman	ARCADIS
Steve Hicks	ARCADIS
Patrick Ryan	Perkins Coie LLP

1. Project Management (Group A)

1.1 Project/Task Organization (A4)

This section presents the organization structure and lines of communication that will be followed to implement the residential well sampling activities presented in this Lagoon Evaluation Quality Assurance Project Plan (QAPP).

The Liberty Dairy and H&S Bosma Dairy (Dairies) have retained ARCADIS to develop and implement the Lagoon Evaluation QAPP. The QAPP has been developed in accordance with requirements identified in Section III.A of the Statement of Work (SOW) (Appendix B of Administrative Order on Consent (AOC) SDWA-10-2013-0080). The QAPP was prepared in accordance with "Guidance for Quality Assurance Project Plans (QA/G-5)" (EPA 2002) and "EPA Requirements for Quality Assurance Project Plans (EPA QA/R-5) (EPA 2001, reissued May 2006). To ensure usability, completeness, and compliance with U.S. Environmental Protection Agency (EPA) guidance, QAPP elements are designated throughout this document by EPA guidance-defined groups, identified by numbers in parentheses next to headings and titles (e.g., A1, A2). In addition to the above guidance, data quality objectives (DQOs) were developed using the requirements included in the SOW and in accordance with the "Guidance on Systematic Planning Using the Data Quality Objectives Process (QA/G-4)" (EPA 2006).

The Project Coordinator (PC) will be responsible for the implementation of activities identified in the QAPP and will maintain communication with the EPA PC as required to communicate progress and resolve issues that may arise during the implementation of the QAPP, if necessary. The PC has overall authority over the project team and implementation of the QAPP.

The Quality Assurance Manager (QAM) will assist in the development and review of project planning documents, evaluation of data, and preparation of deliverables.

No physical samples will be collected for analysis under the QAPP and therefore, no laboratory analysis will be conducted. All physical measurements will be collected by either surveyors or using direct measurement and data logging devices in the field during the implementation of the QAPP.

The Site Safety Coordinator/Sampling Team Leader (SSC/STL) will lead the project field team. The field team will implement the QAPP and Health and Safety Plan (HSP).

The PC and QAM will develop appropriate corrective actions to address any potential quality assurance issues or deficiencies that may occur. Corrective actions will be communicated to the EPA PC and will be implemented and documented by the STL and/or field team, as required.

1.2 Problem Definition/Background (A5)

1.2.1 Purpose

This QAPP defines and describes that processes and methods that will be employed to perform lagoon evaluations required under Section III.F.6 of the AOC SOW. The QAPP was developed to document the type, quantity, and quality of data needed to meet project objectives and support key decisions, and describes the methods for collecting and assessing data collected as part of QAPP implementation.

1.2.2 Problem Statement

Pursuant to Section III.F.6 of the AOC SOW, the Liberty Dairy and H&S Bosma Dairy submitted to the USEPA a Lagoon Review Report (Version 2, August 8, 2013) to provide available lagoon design and construction documentation regarding the compliance of facility lagoons with WA NRCS 313 standards, in particular, soil permeability rates (not to exceed 1×10^{-6} centimeters per second [cm/sec]). The majority of the lagoons at the Dairies Dairy were constructed prior to the current WA NRCS 313 standards for permeability. Therefore, design and construction documents were not available to demonstrate compliance with the current WA NRCS 313 requirements for permeability. In accordance with Section III.F.6 of the AOC SOW, the Dairies are required to submit and implement a Lagoon Evaluation Plan that will be used to determine whether the remaining lagoons at the facility meet the current WA NRCS 313 standard for permeability. The lagoons at the Liberty Dairy that are to be included in the evaluation include (Figure 1A):

- Red Water Pond
- Lagoon 14
- Lagoon 15
- Lagoon 16
- Lagoon 17
- Lagoon 18

The lagoons at the H&S Bosma Dairy that are to be included in the evaluation include (Figures 1B and 1C):

- Lagoon 1
- Lagoon 2
- Lagoon 3
- Lagoon 4A
- Lagoon 4B
- Lagoon 5
- Lagoon 6
- Lagoon 7
- Lagoon 8
- Lagoon 9
- Lagoon 10
- Lagoon 11
- Lagoon 12
- Lagoon 13
- Lagoon 19
- Lagoon 20

The above lagoons will be evaluated under this Lagoon Evaluation QAPP. Lagoons that are found to meet the current WA NRCS 313 permeability standard will require no further action. For lagoons that may be found not to meet the current WA NRCS 313 permeability standard, the Dairies will develop and implement a Lagoon Work Plan that will address lagoon leakage to meet the current WA NRCS 313 standard by lining or other leakage control measures.

1.3 Project/Task Description and Schedule (A6)

1.3.1 Project/Task Description

The scope of the Lagoon Evaluation includes the collection and analysis of physical data to evaluate the permeability of the lagoons listed in Section 1.2 and shown in Figure 1.

Activities to be performed as part of the Lagoon Evaluation are as follows:

- Topographic surveying of the dimensions and liquid levels of facility lagoons and measurement device locations and elevations
- Installation and operation of a weather station at the facility to collect meteorological data for evaporation rate estimation
- Installation and operation of a Class A Evaporation Pan at the facility to collect physical evaporation data for evaporation rate estimation

- Installation and operation of lagoon liquid level measurement devices
- Performance of a "falling head" test at each lagoon (Section 2.2)
- Analysis of data and calculation of permeability for each lagoon (Section 2.1)

1.3.2 Project Schedule

Task	Start Date	Completion Date
Lagoon Surveying and Liquid Level Measurement Devices/Stations Installation	Upon EPA Approval of the QAPP	Within 30 days following EPA approval of the QAPP
Lagoon Testing - Group 1	Spring 2014 – Following spring wet-weather period and prior to Spring irrigation	15 days following start of test
Lagoon Testing - Group 2	2-3 days following completion of Group 1	15 days following start of test
Lagoon Testing – Group 3	2-3 days following completion of Group 2	15 days following start of test
Lagoon Testing – Group 4	2-3 days following completion of Group 3	15 days following start of test
Lagoon Testing – Group 5	2-3 days following completion of Group 4	15 days following start of test
Lagoon Testing – Group 6	2-3 days following completion of Group 5	15 days following start of test
Lagoon Testing – Group 7	2-3 days following completion of Group 6	15 days following start of test
Lagoon Evaluation Report	Upon completion of Group 3 testing	60 days after completion of testing
Lagoon Work Plan	Upon EPA approval of Lagoon Evaluation Report	120 days after EPA approval of Lagoon Evaluation Report

1.4 Quality Objectives and Criteria (A7)

1.4.1 Project Quality Objectives

Project-specific Data Quality Objectives (DQOs) were identified through the DQO process (EPA 2006) to meet the data user's needs for each activity. The specific data needs for the Lagoon Evaluation focus on the collection of data necessary to conduct "falling head" permeability testing for each lagoon using a water balance method of evaluation. The DQO decision-making process for the Lagoon Evaluation is presented in Appendix A.

1.4.2 Measurement Performance Criteria

Measurement performance criteria are often expressed in terms of data quality indicators. The principal indicators of data quality are precision, accuracy, representativeness, comparability, and completeness (PARCC criteria). The following are definitions for the assessment of data quality indicators summarized from "Guidance for Quality Assurance Project Plans (EPA QA/G-5) (EPA 2002):

Precision is the measure of agreement among repeated measurements of the same property under identical or substantially similar conditions and is calculated as either the range or standard deviation.

Accuracy is a measure of the overall agreement of a measurement to a known value. It includes a combination of random error (precision) and systematic error (bias) components of both sampling and analytical operations.

Representativeness is a qualitative term that expresses the degree to which data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, a process conditions, or an environmental condition.

Comparability is a qualitative term that expresses the measure of confidence that one data set can be compared to another and can be combined for the decision to be made.

Completeness is a measure of the amount of valid data needed to be obtained from a measurement system.

Laboratory analysis will not be performed as part of the Lagoon Evaluation. However, for critical data points (such as, liquid elevations and resultant surface areas) multiple measurement methods will be employed (such as, pressure transducers, staff gauges, and survey markers to record liquid levels throughout the testing period) to provide data comparison points. In addition, multiple calculation methods will be used to evaluate the data collected (evaporation estimates using evaporation pan and weather station data and ranges of permeability using different lagoon conditions) as discussed later in Sections 2.1 and 2.2.

1.5 Special Training/Certification (A8)

All personnel working on the project site will be trained in health and safety in accordance with the Health and Safety Plan (HSP). All personnel will comply with the requirements included in the HSP regarding site-specific hazards and conditions. Training requirements, documentation, and tracking are included in the HSP.

1.6 Documents and Records (A9)

All field activities will be documented in field notebooks and the appropriate field forms. Field documentation may include, but is not limited to:

- Lagoon staff gauge measurement logs

All field team-generated documentation will be compiled and submitted to the STL and PC for distribution, inclusion in the project records, and use in subsequent reporting.

2. Data Generation and Acquisition (Group B)

2.1 Evaluation Design (Experimental Design) (B1)

The Lagoon Evaluation design was developed using the DQO process (Appendix A) to ensure that the appropriate types, quantity, and quality of data are collected to answer the principal question of the Lagoon Evaluation (as detailed in Section 1.2.2). The field activity and evaluation strategy has been designed to ensure that all lagoons at the facility that contain liquids that may come into contact with animal wastes are evaluated to determine their permeability with respect to the current WA NRCS 313 permeability requirements.

The Lagoon Evaluation will be used to determine the permeability of each lagoon for the purpose of comparison with the current WA NRCS 313 permeability requirement ($1x10^{-6}$ cm/sec). The Lagoon Evaluation will use industry-standard calculations based on physical measurements of lagoon conditions during the testing period. These calculations are based on a water balance approach detailed in *Seepage Losses from Animal Waste Lagoons: A Summary of a Four-Year Investigation in Kansas* (Ham, 2002a). Evaluation of data will begin with calculating a water balance for the lagoon to determine the seepage rate, followed by calculation of the permeability of the lagoon.

2.1.1 Water Balance Calculation

The following calculation will be used to determine seepage rate from each lagoon during the testing period (Ham, 2002a):

$$\text{Seepage Rate} = \frac{\text{Precipitation} - \text{Change in Liquid Depth} - \text{Cumulative Evaporation}}{\text{Duration of Test}}$$

The methodology used to determine that various parameters in the above calculation are discussed below.

Precipitation

Precipitation during the testing period will be measured using an on-site weather station installed at the facility near the center of all lagoons to be tested as part of the lagoon evaluation plan. The on-site weather station will be installed prior to the initiation of the testing period and will run continuously until testing is complete at the facility. Installation and operation of the on-site weather station is discussed in further detail in Section 2.1 and Appendix B. In the event that a significant precipitation event occurs that results in more than the direct input of precipitation into the lagoon (overland flow) it may be necessary to restart the lagoon testing period if changes to lagoon liquid elevations occur.

Cumulative Evaporation

The cumulative evaporation during the testing period will be estimated using data collected from the on-site weather station (Section 2.2.2 and Appendix B) and the Class A Evaporation Pan (Section 2.2.2 and Appendix C).

Class A Evaporation Pan evaporation rates will be corrected using a pan coefficient to address differences between pan and lagoon evaporation rates. The Class A Evaporation Pan evaporation measured during the testing period will be multiplied by a correction factor of 0.9. The correction factor of 0.9 is sourced from *Water in Environmental Planning* (Dunne and Leopold, 1978) and *Water-Use Estimates Based on Open-Water Evaporation and Evaporation Losses* (USGS, 2006).

Weather station data will be used to provide estimates of evaporation losses using the Food and Agriculture Organization (FAO) Evapotranspiration Calculator Version 3.2 (FAO, 2012). Correction factors will be applied to the Evapotranspiration Calculator-generated evaporation rates using the guidance developed for the FAO by Allen and others (1998). The two correction factors available in the FAO guidance that most closely bracket conditions anticipated at the facility are:

- Correction factor = 1.05 – Evaporation for shallow water ponds (less than 2 meters)

- Correction factor = 0.65 – Evaporation for deep water ponds (greater than 5 meters)

Change in Liquid Depth

The change in liquid depth in the lagoon will be measured by comparing the liquid elevation in the lagoon at the beginning of the testing period with the liquid elevation in the lagoon at the end of the testing period. The lagoon liquid elevation at the beginning and end of testing will be measured using three different methods to increase the level of confidence in elevation measurements:

- Surveyed pin flags placed near the center of each lagoon side at the liquid surface elevation at the beginning and end of testing.

- A pressure transducer located in a stilling well within each lagoon and operated during the entire testing period.

- Visual measurements made using a dedicated staff gauge located within each lagoon during the testing period.

Additional details regarding the installation and operation of the different liquid level elevation measurements are presented in Section 2.2.3 as well as Appendix D.

Duration of Test

The lagoon testing period will be 15 days. The time of initiation and ending of testing will be recorded and will be applied to visual measurements (liquid level pin flag placement and staff gauge readings) and continuously recording measurements (weather station and pressure transducers).

2.1.2 Permeability Calculation

A total of 3 seepage rates will be calculated for each lagoon based on data collected during the testing period. The three different seepage rates will be based on the three methods used to determine evaporation. The lagoon permeability will be calculated for each of the seepage rates to provide a range of lagoon permeability values. The following equation (Ham, 2002a) will be used to calculate lagoon permeability:

$$K_s = \frac{S'A}{\left[A_s\left(\frac{H'}{2L}+1\right)+A_b\left(\frac{H'}{L}+1\right)\right]}$$

Where:

- K_s = Lagoon bottom permeability (m/s)
- S' = Seepage rate (m/s)
- A = Area of liquid surface
- A_s= Areal area of the submerged side embankments (m^2)
- A_b= Areal area of the bottom of the lagoon (m^2)
- H'=Liquid depth above the bottom of the lagoon (m)
- L=Thickness of the lagoon bottom (m)

K_s will be calculated for both beginning and end of test conditions (different A, A_s, and H' values) to provide a range of K_s for each lagoon over the testing period for each of the S' values determined from the water balance (Section 2.1.1) for the evaporation rates from the evaporation pan, weather station evaporation rate using less than 2 meter deep pond, and weather station evaporation rate using greater than 5 meter

deep pond. Therefore, a total of 6 lagoon permeabilities (K_s) will be calculated for each lagoon. These K_s values will be compared against the K_s value of 1×10^{-6} cm/sec WA NRCS 313 standard permeability.

Details regarding the calculation, measurement and development of each of the variables needed to complete the permeability calculation are described below:

- **S'** (seepage rate) will determined by the water balance calculation presented in Section 2.1.1. During testing, no inputs or outputs from the lagoon will occur with the exception of precipitation, evaporation, and seepage. The change in elevation of the lagoon surface during the testing period will be measured with a pressure transducer, manual staff gauge readings, and surveyed elevation points. The change in elevation will be divided by the duration of the testing period (15 days) to determine the seepage rate.

- **A** (area of liquid surface) will be determined from survey data. The liquid surface area will be calculated for both beginning and end of test conditions using the lagoon dimension survey information.

- **A_s** (areal area of submerged side embankments) will be determined from survey data. A_s will be calculated for both beginning and end of test conditions. A_s will be determined by subtracting A_b (areal area of the bottom of the lagoon) from A (area of liquid surface) at both beginning and end of test conditions.

- **A_b** (areal area of the bottom of the lagoon) will be determined from survey data. Because the lagoons often have sloping floors, the boundary for A_b will be the break point between the lagoon side slopes and relatively flat lagoon bottom.

- **H'** (liquid depth above bottom of the lagoon) will be determined by survey, staff gauge, and pressure transducer measurements. H' will be measured from the lowest lagoon bottom elevation. H' representing both beginning and end of test conditions will be used to calculate K_s as noted above.

- **L** (thickness of the lagoon bottom) will be assumed to be 0.3 meters (approximately 1 foot). This assumption is from Ham, 2002a and is intended for use on lagoons where construction information is not available.

2.2 Data Collection Methods (B2)

This section presents the data collection methods that will be used for the collection of required inputs to calculate lagoon permeability presented in Section 2.1.

2.2.1 Lagoon Topographic and Liquid Elevation Measurement Equipment Surveying

All lagoons to be tested as part of the Lagoon Evaluation will be surveyed prior to testing to determine the lagoon dimensions. Because the majority of the lagoons will be filled to near capacity prior to the actual testing period, lagoon dimension surveying and measurement device installation and surveying will be conducted in the late fall/early winter time period when lagoons liquid levels are at their minimum.

During lagoon dimension surveying, particular attention will be given to the break point between the side slopes and the bottom of the lagoon. These data points are critical for determining the areal area of the bottom and side slopes that will be used in lagoon permeability calculations. Because the majority of lagoon bottoms are sloping or slightly sloping, the break point between the side slopes and the flatter lagoon bottom will be used to delineate the difference between lagoon bottom and lagoon side areas. The lowest point of the lagoon bottom will be used to determine the liquid level in the lagoon during the testing period.

All lagoon-specific survey information will be recorded in a local coordinate system for the facility. Horizontal measurements will be accurate within 1.0 foot and vertical measurement will be accurate within 0.01 feet. The local coordinate system will be converted to the Washington State Plane Coordinate System for horizontal measurements and the North American Vertical Datum of 1988 (NAVD88) for mapping and other purposes by surveying in the base control points used to conduct the survey at the facility.

2.2.2 Evaporation Pan and Weather Station Installation and Operation

A Class A Evaporation Pan and local weather station will be installed at the facility to collect data necessary to calculate evaporation rates. The Class A Evaporation Pan and local weather station will be installed near the center of the area containing lagoons to be evaluated to be as representative as possible of local conditions in the area of interest. The Class A Evaporation Pan and local weather station will be installed prior to the initiation of lagoon testing and will be in continuous operation throughout the lagoon testing period. The Class A Evaporation Pan and weather

station will be installed and operated in accordance with their respective Standard Operating Procedures (SOPs), included in Appendices B and C.

2.2.3 Lagoon Testing

Prior to testing, each lagoon to be evaluated will be filled and maintained at operating level with liquid for a minimum of 2 weeks prior to initiation of lagoon testing. This stabilization period allows reduces potential confounding data that may result from initial saturation of previously unsaturated areas of the lagoon bottoms and sides and acts as a stabilization period for the lagoon. If a lagoon is not properly stabilized prior to testing, seepage rates may be inconsistent and could result in inaccurate test results (Ham, 2002b).

Following the 2 week stabilization period, the lagoon will be ready to initiate testing. At this time, all withdrawals and other outputs from the lagoons, with the exception of seepage and evaporation will be halted. All potential inputs of liquids to the lagoon, with the exception of precipitation, will be diverted around the lagoon using pumps, sumps, and/or piping.

Prior to testing, pressure transducer stilling wells and staff gauges will be installed. Efforts will be made to install the pressure transducer and staff gauges near the lowest point in the lagoon to the extent practicable based on lagoon liquid levels and soil conditions within the lagoon at the time of installation. Pressure transducer stilling wells and staff gauges will be installed in accordance with the SOP (Appendix D). The locations and elevations of the staff gauges will be surveyed after installation.

The following will occur at the initiation of testing:

1. Pin flags will be installed at the liquid surface elevation near the center of each of the lagoon sides (total of 4 pin flags).
2. A manual measurement of the elevation of the liquid in the lagoon will be made using the staff gauge and recorded in the Lagoon Staff Gauge Measurement Log.
3. The pressure transducer will be initiated to begin readings on 15-minute intervals and logging will begin.
4. The time that Steps 1 through 3 are performed will be recorded in the field log book and on the Lagoon Staff Gauge Measurement Log.

Lagoon testing will continue until 15 days have elapsed. During the testing period, staff gauge measurements will be recorded on a daily basis. The staff gauge measurement and time of reading will be recorded on the Lagoon Staff Gauge Measurement Log.

At the end of the 15-day lagoon testing period, the following will occur:

1. Pin flags will be installed at the liquid surface elevation near the center of each of the lagoon sides (total of 4 pin flags).
2. A manual measurement of the elevation of the liquid in the lagoon will be made using the staff gauge and recorded in the Lagoon Staff Gauge Measurement Log.
3. The pressure transducer data that has been recorded during the testing period will be downloaded and recording stopped.
4. The time that Steps 1 through 3 are performed will be recorded in the field log book and on the Lagoon Staff Gauge Measurement Log.
5. The 8 pin flags will be surveyed following the testing period and prior to refilling of the lagoon for normal dairy operations.

Testing of lagoons at the Dairies will be performed by dividing the lagoons to be tested in seven groups. This will allow normal operations at the dairy to occur during the testing process. Each group will be tested for a period of 15 days. It is anticipated that a period of 2-3 days will be required between testing groups to allow liquids to be transferred between lagoons prior to the initiation of testing. The testing groups and lagoons included in each group are as follows:

- Group 1 – Lagoons 4A, 16, and 20
- Group 2 – Lagoons 4B, 17, and 19
- Group 3 – Lagoons 5, 8, 9, and 15
- Group 4 – Lagoons 6, 11, and 14
- Group 5 – Red Water Pond and Lagoons 3 and 10
- Group 6 – Lagoons 2, 7, and 13
- Group 7 – Lagoons 1, 12, and 18

2.3 Sample Handling and Custody (B3)

No samples are being collected as part of the Liberty Dairy and H&S Bosma Dairy Lagoon Evaluation.

2.4 Analytical Methods (B4)

No samples are being collected for laboratory analysis as part of the Liberty Dairy and H&S Bosma Dairy Lagoon Evaluation.

2.5 Quality Control (B5)

No samples are being collected for laboratory analysis as part of the Liberty Dairy and H&S Bosma Dairy Lagoon Evaluation.

Quality control has been built into the evaluation by using multiple methods to evaluate evaporation rates and lagoon liquid surface elevations.

Evaporation rates will be determined from data collected using a Class A Evaporation Pan and on-site weather station data. Further, the on-site weather station data will be used to calculate evaporation rates using two different conditions that will be representative of conditions at the site (ponds less than 2 meters deep and ponds greater than 5 meters deep). This provides multiple points of reference for comparison for the calculated permeability results.

Three different methods will be employed to record lagoon liquid elevations over the testing period: manual staff gauge readings, 15-minute interval pressure transducer readings, and surveyed liquid elevations for beginning and end of test conditions. All three measurements will be compared to one another using standard plotting software with elevation on the y-axis and time on the x-axis. If inconsistencies are encountered, they will be resolved by the QAM and PC and communicated to the EPA PC.

2.6 Instrument/Equipment Testing, Inspection, and Maintenance

All instruments and equipment used as part of the Liberty Dairy and H&S Bosma Dairy Lagoon Evaluation will be tested, inspected, and maintained in accordance with manufacturer instructions and SOPs (Appendices B through D).

2.7 Instrument/Equipment Calibration and Frequency

All instruments and equipment used as part of the Liberty Dairy and H&S Bosma Dairy Lagoon Evaluation will be calibrated in accordance with and at the frequency indicated in the manufacturer instructions.

2.8 Inspection/Acceptance of Supplies and Consumable (B8)

Supplies and consumables that may be used during the Liberty Dairy and H&S Bosma Dairy Lagoon Evaluation will be inspected by ARCADIS and/or Liberty Dairy and H&S Bosma Dairy personnel upon receipt.

2.9 Non-direct Measurements (B9)

No pre-existing data will be used to make decisions in support of the Liberty Dairy and H&S Bosma Dairy Lagoon Evaluation. All data used to support decision-making will be collected during the Liberty Dairy and H&S Bosma Dairy Lagoon Evaluation.

2.10 Data Management (B10)

All field data collected during the Liberty Dairy and H&S Bosma Dairy Lagoon Evaluation will be recorded on field forms as discussed in previous sections and included in Appendix F. Data collected from pressure transducers, weather stations, and other data recording devices used in the Liberty Dairy and H&S Bosma Dairy Lagoon Evaluation will be transferred to an Excel spreadsheet or similar electronic data management tool.

3. Assessment and Oversight (Group C)

3.1 Assessments and Response Actions (C1)

The PC and QAM will monitor the performance of the QA procedures presented in this QAPP. The PC has the ultimate responsibility for implementation of this QAPP. If problems arise, or if directed by the PC, the QAM will conduct a field audit for the purpose of evaluating compliance with the guidance presented in this QAPP.

3.2 Reports to Management (C2)

A Liberty Dairy and H&S Bosma Dairy Lagoon Evaluation Report will be created that documents the following:

- All lagoons tested during the Lagoon Evaluation
- Calculated permeability results for each lagoon tested
- Data and calculations used to calculate lagoon permeability
- Identification of lagoons that meet or do not meet the current WA NRCS 313 permeability standard.

4. Data Validation and Usability (Group D)

No laboratory samples are being collected as part of the Liberty Dairy and H&S Bosma Dairy Lagoon Evaluation Plan. As noted in Section 2.5, multiple data collection and calculation methods are being employed during the Lagoon Evaluation. These methods and their results will be compared to evaluate the usability of the data.

5. References Cited

Allen, R.G., L.S. Pereira, D. Raes, and M. Smith. 1998. Crop evapotranspiration – guidelines for computing crop water requirements – FAO irrigation and drainage paper 56. Food and Agricultural Organization of the United Nations. Rome. http://www.fao.org/docrep/X0490E/x0490e00.htm

Dunne and Leopold. 1978. Water in Environmental Planning. W.H. Freeman and Company, New York.

U.S. Environmental Protection Agency (EPA). 2001. EPA Requirements for Quality Assurance Project Plans (EPA QA/R-5). Office of Environmental Information, Washington, D.C. EPA/240/B-01/1003. March (reissued 2006).

EPA. 2002. Guidance for Quality Assurance Project Plans (EPA QA/G-5). Office of Environmental Information, Washington, D.C. EPA/240/R-02/009. December.

EPA. 2006. Guidance on Systematic Planning Using Data Quality Objectives Processes (EPA QA/G-4). Office of Environmental Information, Washington, D.C. EPA/240/B-06/001. February.

EPA. 2010. National Functional Guidelines for Inorganic Superfund Data Review. EPA/540/R-10/011. Contract Laboratory Program. January.

EPA. 2013. Administrative Order on Consent (AOC) Docket No. SDWA-10-2013-0080, March 19.

FAO. 2012. ETo calculator. Land and Water Digital Media Series $N^0$36. Food and Agricultural Organization of the United Nations. Rome, Italy. Available online at: http://www.fao.org/nr/water/ETo.html

U.S. Geological Survey. 2006. Water-Use Estimates Based on Open-Water Evaporation and Evapotranspiration Losses.

Ham, J.M. 2002a. Seepage Losses from Animal Waste Lagoons: A Summary of a Four-Year Investigation in Kansas. Transactions of the American Society of Agricultural Engineers. Vol. 45(4): 983-992.

Ham, J.M. 2002b. Uncertainty Analysis of the Water Balance Techniques for Measuring Seepage from Animal Waste Lagoons. Journal of Environmental Quality. Vol. 31: 1370-1379.

6. Certifications

6.1 Liberty Dairy Certification

I certify under the penalty of law that this document and all attachments were prepared by me or under my direction or supervision in accordance with a system designed to assure that qualified personnel gathered and evaluated the information submitted. Based on my inquiry of any and all persons directly responsible for gathering and analyzing the information obtained, I certify that the information contained in or accompanying this submittal is to the best of my knowledge and belief, true, accurate and complete. As to those identified portion(s) of this submittal for which I cannot personally verify the accuracy, I certify that this submittal and all attachments were prepared in accordance with procedures designed to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person or persons who manage the system, or those directly responsible for gathering the information, or the immediate supervisor of such person(s), the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Liberty Dairy, LLC and its associated dairy facility
H & S Bosma Dairy

Signature: _____

Name: Henry Bosma

Title: Partner

Date: _____

SOURCE: WASHINGTON 2011 NAIP ORTHO-IMAGERY-18 INCH DATA, WASHINGTON STATE ORTHOIMAGE PORTAL [HTTP://GEOGRAPHY.WA.GOV/ORTHO]

0 500' 1000'

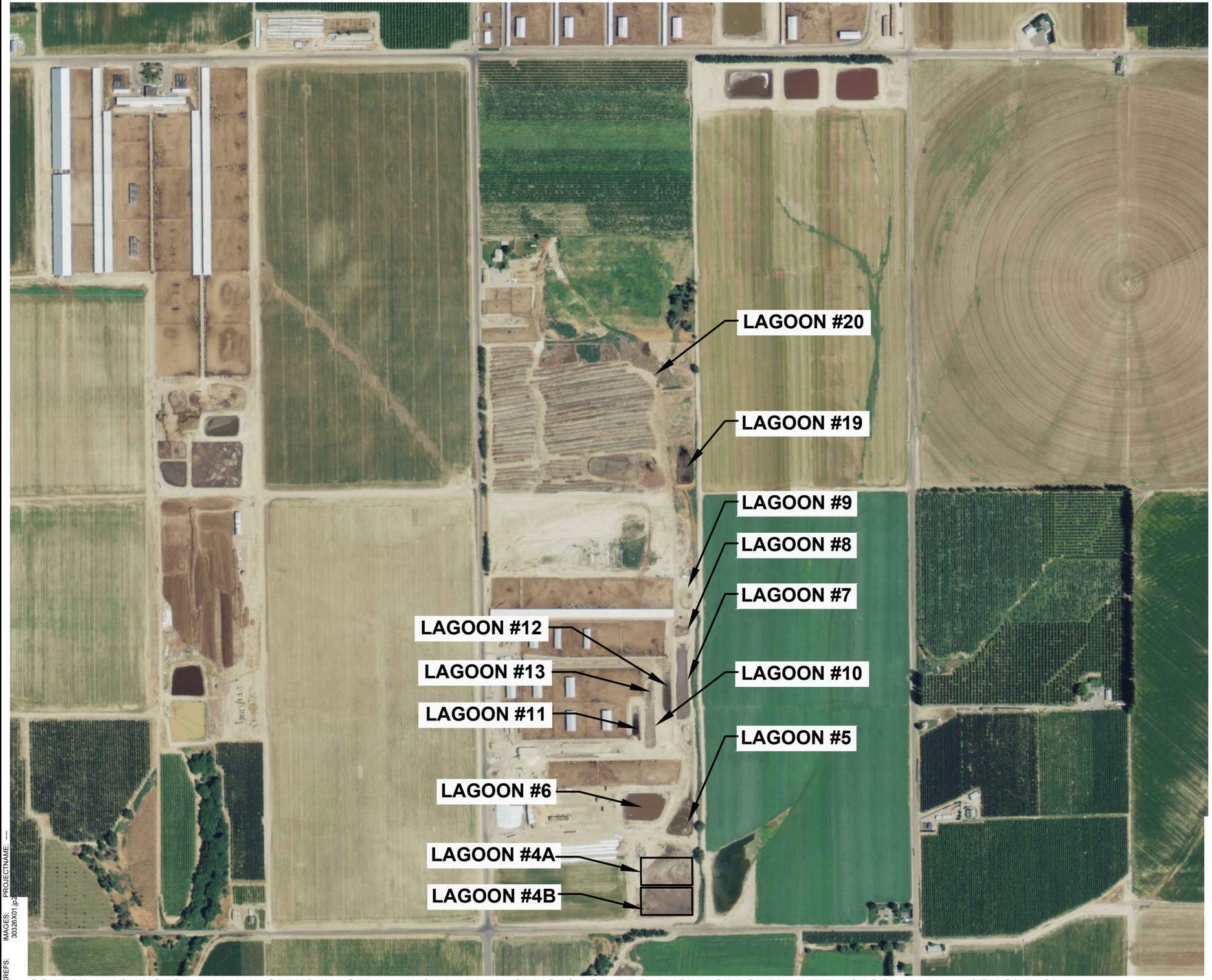
GRAPHIC SCALE

LIBERTY DAIRY, LLC
5860 EAST SILLAH DRIVE
ZILLAH, WA 98953

LAGOON MAP

ARCADIS

FIGURE
1A



SOURCE: WASHINGTON 2011 NAIP ORTHO-IMAGERY-18 INCH DATA, WASHINGTON STATE ORTHOIMAGE PORTAL [HTTP://GEOGRAPHY.WA.GOV/ORTHO]

0 600' 1200'

GRAPHIC SCALE

H & S BOSMA DAIRY
1271 LIBERTY ROAD
GRANGER, WA 98932

LAGOON MAP

ARCADIS

FIGURE
1B

SOURCE: WASHINGTON 2011 NAIP ORTHO-IMAGERY-18 INCH DATA, WASHINGTON STATE ORTHOIMAGE PORTAL [HTTP://GEOGRAPHY.WA.GOV/ORTHO]

0 300' 600'
GRAPHIC SCALE

H & S BOSMA DAIRY
1271 LIBERTY ROAD
GRANGER, WA 98932

LAGOON MAP

ARCADIS

FIGURE
1C

Appendix A

Data Quality Objectives

Appendix A – Data Quality Objectives for Liberty – H&S Bosma Lagoon Evaluation Plan

Step 1: State the Problem	*Description of the Problem:* Pursuant to Section III.F.6 of the Administrative Order on Consent (AOC) Scope of Work (SOW) (SDWA-10-2013-0080), the Liberty Dairy and H&S Bosma Dairy have submitted to the USEPA a Lagoon Review Report (Version 2, August 8, 2013) to provide available lagoon design and construction documentation regarding the compliance of facility lagoons with the current WA NRCS 313 standards, in particular, soil permeability rates (not to exceed $1x10^{-6}$ cm/sec). The results of the Lagoon Review Report showed that no lagoons within either dairy had sufficient design or construction documentation to demonstrate that it complied with the WA NRCS 313 permeability requirements. The lagoons at the Liberty Dairy and H&S Bosma Dairy were constructed prior to the current WA NRCS 313 standards for permeability. Therefore, design and construction documents were not available to demonstrate compliance with current WA NRCS 313 requirements for permeability. In accordance with Section III.F.6 of the AOC SOW, the Liberty Dairy and H&S Bosma Dairy are required to submit a Lagoon Evaluation Plan that will be used to determine whether the remaining lagoons at the facilities meet the current WA NRCS 313 standard for soil permeability. The lagoons at the Liberty Dairy that are to be included for evaluation include (Figure 1A): • Red Water Pond • Lagoon 14 • Lagoon 15 • Lagoon 16 • Lagoon 17 • Lagoon 18 The lagoons at the H&S Bosma Dairy that are to be included for evaluation include (Figures 1B and 1C): • Lagoon 1 • Lagoon 2 • Lagoon 3 • Lagoon 4A • Lagoon 4B • Lagoon 5 • Lagoon 6 • Lagoon 7 • Lagoon 8 • Lagoon 9 • Lagoon 10 • Lagoon 11 • Lagoon 12 • Lagoon 13 • Lagoon 19 • Lagoon 20

	Conceptual Model: Manure and water management at the Liberty Dairy and H&S Bosma Dairy is accomplished using a combination of catch basins, settling basins, and liquid manure lagoons. Stormwater runoff from animal holding pens, solid manure composting areas, silage storage areas, and roadways within the dairy are collected in catch basins and collection systems located throughout the facility. Stall and alleyway flush water as well as collected water is then conveyed to the liquid manure management system. Manure and other liquids from the facilities is collected and routed to a series of screens to remove as much of the solid portion of the manure as possible. Following screening, the solids are collected and composted at the facility along with manure and bedding materials scraped from the animal holding pens. The liquids remaining after screening are routed through settling basins (Lagoons 15, 16, and 17) to provide an opportunity for small solids that passed the screens to settle out of the liquid manure. Following the settling basins, liquid manure is directed to the liquid manure lagoons (Lagoons 1, 2, 3, 4A, 4B, 14, and Red Water Pond) for holding prior to land application. *Planning Team:* The Liberty Dairy and H&S Bosma Dairy Lagoon Evaluation Plan was developed by a team of scientists and engineers using the systematic planning process. The planning team included the Dairy staff, scientists, and engineers. The Liberty Dairy and H&S Bosma Dairy Lagoon Evaluation Plan data quality objectives (DQOs) generated using the systematic planning process were shared with EPA for review, input, and approval prior to finalization of the Liberty Dairy and H&S Bosma Dairy Lagoon Evaluation Plan. *Resources and Schedule:* The Liberty Dairy and H&S Bosma Dairy Lagoon Evaluation Plan was developed in the fall of 2013 and is scheduled for implementation by the Dairy upon approval by EPA. It is anticipated that because of manure and water management requirements for the Dairy under the Nutrient Management Plan that implementation will occur in the late spring/early summer of 2014.
Step 2: Identify the Decision	*Principal Study Question:* Do the lagoons located at the Liberty Dairy and H&S Bosma Dairy meet the soil permeability requirements identified in the current WA NRCS 313? *Alternative Outcomes:* • No Action – lagoon meets the current WA NRCS 313 permeability standard • Develop Lagoon Work Plan – lagoon does not meet the current WA NRCS 313 permeability standard and methods to address lagoon leakage to comply with the standard will be developed and implemented.

	Decision Statements: 1. If the lagoon permeability, determined by testing, is less than $1x10^{-6}$ cm/sec; then the lagoon meets the current WA NRCS 313 requirements and no further action is necessary. 2. If the lagoon permeability, determined by testing, is greater than $1x10^{-6}$ cm/sec; then the lagoon does not meet current WA NRCS 313 requirements and a Lagoon Work Plan will be developed and implemented to address lagoon leakage to meet the current WA NRCS 313 standard by lining the lagoon or other leakage control measures.

Step 3: Identify Inputs to the Decision	*Type of information needed (source in parentheses):*
	• Location of each lagoon to be evaluated
	• Topographic survey of lagoon to delineate the surface area and elevation of the liquid surface at beginning and end of testing, elevation of lagoon bottom, areal area of lagoon bottom, and area area of lagoon side slopes at the beginning and end of testing (survey)
	• Elevation of lagoon water surface (surveyed staff gauge and transducer)
	• Liquid inputs (flow meters on inlets/pumps) – inputs will be held at zero or minimized to the extent practicable during testing period
	• Liquid outflows (flow meters on outlets/pumps) – withdrawals from the lagoons will not occur during testing to the extent practicable
	• Evaporation rate (evaporation pan and weather station)
	• Meteorological data (weather station)
	  ○ Precipitation
	  ○ Temperature
	  ○ Wind speed
	  ○ Relative humidity
	  ○ Solar radiation
	
	Determination of Action Level:
	• The action level will be based on the permeability of the lagoon calculated from measured water balance information obtained during the test. The calculated permeability will be compared with the current WA NRCS 313 permeability standard of $1x10^{-6}$ cm/sec.
	
	Appropriate Sampling and Analysis Methods:
	• Water Balance:
	  ○ Inputs: Water/manure inputs can be easily measured by flow meters and/or calculations based on pump size and electricity use. During testing, every effort will be made to limit water/manure inputs to the initial filling or "topping off" of the lagoons. All manure/water will be routed to other lagoons not undergoing testing during the testing period to the extent practicable. Inputs from precipitation can be calculated based on surface area (measured by survey) and precipitation amount (measured by weather station). In the event that a significant precipitation event occurs that results in overland or storm flow

	to the lagoon, the volume may be calculated based on change in lagoon elevation, precipitation, and catchment area. However, if there is low certainty regarding potential inputs resulting from significant precipitation events, then the test period may need to be adjusted to either censor the time period when the significant precipitation event occurred or to restart the time period of the test to conditions following the significant precipitation event. ○ Outputs: No active withdrawals will be made from the lagoons during the testing period. The only potential outputs during the test period will be evaporation and seepage through the lagoon sides and bottoms. Evaporation will be measured using a Class A evaporation pan located at the facility and using weather station information from an on-site weather station located near the center of lagoons being tested. • Survey Data: Standard topographic survey techniques are capable of providing a topographic map of the interior of the lagoon, liquid surface elevations, staff gauges, and pressure transducer elevations. All survey data will be recoded using a site-specific coordinate system and translated to Washington State Plane coordinate system for horizontal measurement and North American Vertical Datum 1988 (NAVD 88) for vertical measurement by surveying in benchmarks and base stations used for the site-specific survey. Horizontal survey data will have an accuracy of 1.0 feet and vertical survey data will have an accuracy of 0.01 feet.
Step 4: Define the Boundaries of the Study	*Target Population:* • The target population for the Liberty Dairy and H&S Bosma Dairy Lagoon Evaluation Plan is the permeability of the lagoons that are being evaluated. The permeability will be calculated based on measurements collected during a "falling head" evaluation (lagoons will be filled and no additional inputs will occur during the testing period, with the exception of potential precipitation events). During the evaluation, the only potential outputs during the testing period will be seepage and evaporation. Evaporation will be measured using a Class A evaporation pan and an on-site weather station. Spatial and Temporal Boundaries: • Spatial Boundary: Lagoons identified in the Lagoon Review Report that require evaluation listed in Step 1 and shown in Figures 1A, 1B, and 1C. • Temporal Boundary: Lagoon evaluation testing will be performed according to the schedule set forth in the Lagoon Evaluation Plan. Practical Constraints on Data Collection: • Nutrient Management Plan Requirements: The dairy NMP requires that the dairy enter into the winter period with sufficient capacity in their manure/water management system to contain all potential water that may be generated over the winter and spring when land application does

	not occur. Because of this, there is not sufficient held manure/water available at the dairy to conduct testing during the winter months. Because many of the lagoons may be nearing capacity in the spring, there will be sufficient volumes available to conduct testing and transfer between lagoons to facilitate testing. Based on this, lagoon testing will occur in the late spring/early summer as irrigation activities are beginning. • Precipitation: The majority of precipitation occurring in the area is during the late winter/early spring. It is anticipated that testing will begin following all major precipitation events that may occur. However, if a significant precipitation event occurs that results in overland flow or stormwater runoff into the lagoon during the testing period of a volume that cannot be accurately calculated, then slight delays may occur based on the need to either censor the testing data to remove the event or potentially restarting the test. • Lagoon stabilization – Lagoons must be filled to operating level for a period of 2 weeks to allow the lagoon to stabilize prior to testing. If the lagoon is not properly stabilized, the effect of initial saturation resulting from filling a dry lagoon will result in inconsistent seepage rates (Ham, 2002).
Step 5: Develop a Decision Rule	<u>*Population Parameter of Interest:*</u> The population parameter of interest will be calculated using measurements collected during lagoon testing. Calculation of permeability will be performed using the following equation from *Seepage Losses from Animal Waste Lagoons: A Summary of a Four-Year Investigation in Kansas* (Ham, 2002): $K_s = S'A/[A_s(H'/2L+1)+A_b(H'/L+1)]$ Where: K_s = Lagoon bottom hydraulic conductivity (m/s) S' = Seepage rate (m/s) A = Area of liquid surface A_s= Areal area of the submerged side embankments (m^2) A_b= Areal area of the bottom of the lagoon (m^2) H'=Waste depth above the bottom of the lagoon (m) L=Thickness of the lagoon bottom (m) K_s will be calculated for both beginning and end of test conditions (different A, A_s, and H' values) to provide a range of K_s for each lagoon over the testing period. S' (seepage rate) will determined by water balance. During testing, no inputs or outputs from the lagoon will occur with the exception of precipitation, evaporation, and seepage. The change in elevation of the lagoon surface during the testing period will be used to calculate a change in volume. The volume (adjusted for any potential precipitation input) will be divided by the duration of the test to determine the change in lagoon volume in units of volume per time. The measured and calculated evaporation rates (discussed below) during the test

	period will be subtracted from this value to obtain S'. A (area of liquid surface) will be determined from survey data. The liquid surface area will be calculated for both beginning and end of test conditions. A_s (areal area of submerged side embankments) will be determined from survey data. A_s will be calculated for both beginning and end of test conditions. A_s will be determined by subtracting A_b from A at both beginning and end of test conditions. A_b (areal area of the bottom of the lagoon) will be determined from survey data. Because the lagoons often have sloping floors, the boundary for A_b will be the break point between the lagoon side slopes and relatively flat lagoon bottom. H' (waste depth above bottom of the lagoon) will be determined by survey, staff gauge, and pressure transducer measurements. H' will be measured from the lowest lagoon bottom elevation. H' representing both beginning and end of test conditions will be used to calculated K_s as noted above. L (thickness of the lagoon bottom) will be assumed to be 0.3 meters (approximately 1 foot). This assumption is from Ham, 2002 and is intended for use on lagoons where construction information is not available. Evaporation rates will be calculated from data collected during the testing period. Evaporation rates will be calculated using two different methods: 1. Class A Evaporation Pan 2. On-site weather station data and Food and Agriculture Organization (FAO) evaporation calculator (ETo Calculator. Land and Water Digital Media Series $N^0$36. Rome, Italy. Available online at http://www.fao.org/nr/water/ETo.html [FAO, 2012]) Correction factors will be applied to the calculated evaporation rates in order for them to be representative of actual conditions. The following correction factors were derived from industry-standard references and FAO: 1. Class A Evaporation Pan – Correction Factor = 0.9 (Dunne and Leopold, 1978 and USGS, 2006). 2. FAO Calculator: a. Correction Factor = 0.65 for deep ponds (greater than 5 meters deep) (Allen, 1998) b. Correction Factor = 1.05 for shallow ponds (less than 2 meters deep) (Allen, 1998) The use of three different evaporation rates will provide a bracket for calculated permeability results based on actual site-measured evaporation and evaporation calculations using site-measured weather data that closely represent site lagoon conditions. *Primary Decision Rule:* If the range of calculated permeabilities for the lagoon is less than the current WA NRCS 313 standard of $1x10^{-6}$ cm/sec, then the lagoon meets the current WA

	NRCS 313 requirements and no additional action is necessary. If the range of calculated permeabilities for the lagoon is greater than the current WA NRCS 313 standard of $1x10^{-6}$ cm/sec, then the lagoon does not meet the current WA NRCS 313 requirements and a Lagoon Work Plan will be developed and implemented to address lagoon leakage by lining the lagoon or other leakage control measures.

Step 6: Specify Tolerable Limits on Decision Errors	The Liberty Dairy and H&S Bosma Dairy Lagoon Evaluation Plan was designed to allow the permeability of the lagoons to be determined with a relatively high degree of certainty and for a range of lagoon conditions. Lagoon permeability will be calculated using site-specific data and industry standard calculations. Calculations will be performed for both beginning and end of test conditions to maintain a conservative range. In addition, beginning and end of test permeabilities will be calculated using two different evaporation rate measurement methods:
	• On-stie Class A Evaporation Pan
	• On-site weather station data
	Industry standard calculations and correction factors will be used to provide three estimates of evaporation rates:
	• On-site Class A Evaporation Pan with a correction factor of 0.9
	• FAO ETo calculator evaporation rate with two different correctin factors:
	  ○ 0.65 correction factor for ponds greater than 5 meters deep
	  ○ 1.05 correction factor for ponds less than 2 meters deep
	Given the wide range of calculation methods and the variables that may impact leakage from lagoons, the methods identified in the Liberty Dairy and H&S Bosma Dairy Lagoon Evaluation Plan will limit the potential to overlook lagoons that may have permeability greater than the $1x10^{-6}$ cm/sec current WA NRCS 313 standard.

Step 7: Develop the Plan for Obtaining Data	1. During the winter, a topographic survey will be conducted of all lagoons to be evaluated at the Liberty Dairy and H&S Bosma Dairy under the Liberty Dairy and H&S Bosma Dairy Lagoon Evaluation Plan. The survey will be conducted near the end of the irrigation season when lagoon levels are at their lowest to allow access to the lagoons and to ensure that the bottom elevation and the break point between side embankments and the lagoon bottom can be delineated for area calculation purposes. The remaining survey parameters (liquid surface elevations, staff gauges, pressure transducers) will be staked and surveyed before, during, and after the testing period. 2. Prior to lagoon testing, a Class A evaporation pan and on-site weather station will be installed at a central location between all lagoons to be tested. The evaporation pan and weather station will be operated during the entire testing period. Information regarding operation and data collection from the evaporation pan and weather station are included in Appendicies B, C, and D of the Liberty Dairy and H&S Bosma Dairy Lagoon Evaluation QAPP. Prior to the initiation of testing, a pressure transducer and staff gauge will be installed in each lagoon. Details regarding staff gauge and pressure transducer placement, operation, and data collection are included in Appendicies B, C, and D of the Liberty

	Dairy and H&S Bosma Dairy Lagoon Evaluation QAPP. 3. The Liberty Dairy and H&S Bosma Dairy lagoons will be tested in seven groups. Each group will be tested for a period of 10-14 days depending on observed weather conditions and liquid level changes. a. Group 1: Lagoons 4A, 16, and 20 b. Group 2: Lagoons 4B, 17, and 19 c. Group 3: Lagoons 5, 8, 9, and 15 d. Group 4: Lagoons 6, 11, and 14 e. Group 5: Red Water Pond, Lagoons 3 and 10 f. Group 6: Lagoons 2, 7, and 13 g. Group 7: Lagoons 1, 12, and 18 4. Prior to testing each lagoon in the group will be filled to operating level for a period of 2 weeks. The operating level (fill level) will be staked for survey upon completion of the test. A staff gauge and pressure transducer will be installed in each lagoon and reference elevations will be staked for survey upon completion of the test. 5. After filling, all potential liquid inputs to the lagoon will be diverted away from the lagoon and all outlets closed. 6. During testing, the staff gauge will be observed and measurements recorded on a daily basis. Pressure transducers will be downloaded on a weekly basis (midway through the testing period, and at the end of the test).). After the test has been running for 15 days, the test period will end. The ending liquid elevation will be staked and surveyed. The beginning and ending test times and lagoon elevations will be used to calculate liquid losses during the test period. 7. Upon completion of testing, the next group of lagoons will be filled and the above steps will be repeated for each of the three groups. 8. Data reduction and calculation of lagoon permeability will be conducted in accordance with the process identified in Step 5 above.

ARCADIS

Appendix B

Weather Integrated Sensor
Equipment Installation and Operation

ARCADIS

Infrastructure · Water · Environment · Buildings

Imagine the result

Weather Integrated Sensor Equipment Installation and Operation

Rev. #: 1.0

Rev Date: October 2, 2013

Approval Signatures

Prepared by: _____ Date: _____
Myles Perkins

Reviewed by: _____ Date: _____
Jonathan Burton, PE (Technical Expert)

Reviewed by: _____ Date: _____
John DeJong (Editorial Reviewer)

Reviewed by: _____ Date: _____
Steve Hicks, PE (Quality Assurance Reviewer)

Reviewed by: _____ Date: _____
Kevin Freeman (Project Manager)

I. Scope and Application

Integrated Sensor Equipment (ISE) collects outside weather data that can subsequently be downloaded to a computer or weather envoy. Standard versions of this equipment contain a rain collector, temperature sensor, barometric pressure sensor, humidity sensor, anemometer (wind speed and direction), solar radiation sensor and sensor interface module (SIM). Temperature and humidity sensors are mounted in a passive radiation shield to minimize the impact of solar radiation on sensor readings. The SIM collects and stores outside weather data from the ISE prior to transfer to the weather envoy.

This equipment installation and operating procedure described herein includes guidelines for installation and operation of the ISE and associated components.

II. Personnel Qualifications

ARCADIS field personnel will have current health and safety training, including site-specific training, as needed. In addition, ARCADIS field personnel will be versed in the relevant Standard Operating Procedures (SOPs) and possess the skills and experience necessary to successfully complete the desired fieldwork. The project Health and Safety Plan (HASP) and other documents will identify any other training requirements, such as a site-specific training or access control requirements.

III. Equipment List

- Health and Safety equipment, as required in the site HASP
- ISE components and hardware associated with the site-specific weather station package. At a minimum, the ISE will record: temperature, humidity, barometric pressure, precipitation, wind speed and direction, and solar radiation.
- Small Phillips and/or flat edge screwdriver
- Scissors or wire cutters
- Adjustable wrench
- Bubble level
- Compass or local map of area
- Ballpoint pen or paper clip (or other small pointed object)

- Drill and drill bits
- Anchor stakes
- Properly measured mounting pole, preferably sturdy wood or metal

IV. Cautions

Make sure all components of the site-specific ISE are present and undamaged. If equipment is wet prior to installation, allow to dry before use or storage. If equipment is damaged it should not be used and should be discarded or submitted for repair prior to data collection.

V. Health and Safety Considerations

Read and review the product specific ISE manual prior to installation and use. Follow health and safety procedures outlined in the site-specific HASP.

VI. Procedure

Prior to field mobilization, properly prepare all components and hardware associated with your ISE as described in the product manual. Once all sensors have been connected and communication between the ISE and the SIM has been successfully established, the device can be installed in the field.

Field Installation

For the weather station to perform at its best, use these guidelines to select the optimum mounting locations for the ISE and anemometer. Be sure to take into consideration ease of access for maintenance and sensor cable lengths when installing the station:

General ISE

- Locate the ISE away from sources of heat such as chimneys, heaters, air conditions and exhaust vents.
- Locate the ISS at least 100 feet away from any asphalt or concrete roadway that readily absorbs and radiates heat in the sun. Avoid installation near fences or sides of buildings that receive a lot of sun during the day.

- Ideally, locate the radiation shield of the ISE 5 feet above the ground in the middle of gently sloping or flat, regularly mowed grassy or naturally landscaped area that drains well when it rains. For areas with average maximum yearly snow depths over 3 feet, mount the ISE 2 feet above this depth.
- Never install the ISE where it will be directly sprayed by sprinkler systems.
- Do not locate the ISE under tree canopies or near the side of buildings that create "rain shadows".
- For units with solar radiation sensors, place the ISE in a location with good sun exposure throughout the day.
- Avoid areas exposed to extensive or frequent applications of agricultural chemicals (which can degrade the sensors).
- Install the ISE as level as possible to ensure accurate rain measurements.
- If unit has a solar panel, face the panel south in the northern hemisphere and north in the southern hemisphere
- Secure loose cables to system to prevent fraying or cutting in the wind.
- If using solar radiation and/or UV sensors, verify that these sensors are level using a bubble level.
- If the ISE contains solar radiation and/or UV sensors, do not touch the small white diffuser on top of the sensors. Oil from the skin reduces their sensitivity. If the diffuser is touched, clean it with ethyl alcohol (NEVER use rubbing or denatured alcohols).

Anemometer

- Place the anemometer away from obstructions such as trees or buildings that obstruct wind flow.
- Place the anemometer at least 6.6 feet (2 meters) above the ground surface.
- If mounting the ISE and the anemometer together, such as on a pole, install the ISE such that the anemometer is at least 12 inches above the top of the rain collector cone.

- To ensure correct orientation of the wind vane, mount the anemometer so that the arm points true north.

Depending on the weather station obtained, there may be multiple ways to mount the anemometer and ISE system at the correct height. Refer to the product specific installation manual for guidance.

Maintenance and Troubleshooting

The following guidelines should be used to ensure that ISE sensors are functioning properly.

General Cleaning the Rain Collector Cone

- Separate the cone from the base of the unit.
- Use a soft, damp cloth to remove any debris from the cone, cone screen, and tipping bucket.
- Use pipe cleaners to clear the funnel hole in the cone and drain screens in the base.
- When all parts are clean, rinse with clear water before reassembly.

Cleaning the Radiation Shield

Check the radiation shield for debris or insect nests at least once a year and clean when necessary. A buildup of material inside the shield reduces its effectiveness and may cause inaccurate temperature and humidity readings. Please refer to the product manual for specific cleaning instructions.

Data Recording and Management

A SIM can be used to download and display weather data. Depending on the model, a SIM can display tables, graphs and alarm functions when interfaced with a computer using the product software. Most devices can transfer data using a cable or wireless system. Always refer to the SIM's product manual for specific details prior to installation and operation.

Measurements from the SIM will be recorded at intervals and for a duration as determined by the Project Manager, consistent with the requirements of the investigation. Data will be downloaded from the SIM and loaded to a computer using the product specific software. Periodic data downloading may be instituted depending on the length of the test. Electronic records (downloaded weather data) will be transmitted to the ARCADIS PM as directed by the PM. The employee responsible for data download will retain electronic copies of all downloaded data on the field computer.

VII. References

Davis Instruments. 2010. Integrated Sensor Suite Installation Manual (January 2010).

Davis Instruments. 2010. Vantage Pro2™ Console Manual (January 2010).

ARCADIS

Appendix C

Class A Evaporation Pan Installation and Operation

ARCADIS

Infrastructure · Water · Environment · Buildings

Imagine the result

Class A Evaporation Pan Installation and Operation

Rev. #: 1.0

Rev Date: October 2, 2013

Approval Signatures

Prepared by: _____ Date: _____
Myles Perkins

Reviewed by: _____ Date: _____
Jonathan Burton, PE (Technical Expert)

Reviewed by: _____ Date: _____
John DeJong (Editorial Reviewer)

Reviewed by: _____ Date: _____
Steve Hicks, PE (Quality Assurance Reviewer)

Reviewed by: _____ Date: _____
Kevin Freeman (Project Manager)

I. Scope and Application

Pan evaporation is a measurement that can determine the effect of multiple climate elements, including: Temperature, humidity, rainfall, drought dispersion, solar radiation, and wind. An evaporation pan is used to hold liquid during water level observations during a pan evaporation field event.

This Standard Operating Procedure (SOP) is specifically for a Class A evaporation pan, which is the standard unit used by the National Weather Service. This equipment installation and operating procedures described herein includes guidelines for installation and operation of the Class A evaporation pan.

II. Personnel Qualifications

ARCADIS field personnel will have current health and safety training, including site-specific training, as needed. In addition, ARCADIS field personnel will be versed in the relevant SOPs and possess the skills and experience necessary to successfully complete the desired fieldwork. The project Health and Safety Plan (HASP) and other documents will identify any other training requirements, such as site specific training or access control requirements.

III. Equipment List

- Health and Safety equipment, as required in the site HASP
- Class A evaporation pan with stilling tube (GlobalWater EP180, Novalynx 255-200, or equivalent)
- Evaporation pan platform, constructed to specifications presented in *Novalynx Corporation Model 255-200 Evaporation Pan Instruction Manual*
- Timepiece
- Bubble level
- Gauged (vented) pressure transducer with temperature sensing capabilities (LevelTROLL 700 or equivalent)
- Field computer with transducer data collection and management associated software installed
- Floating thermometer

- 12-inch/30-centimeter (cm) plastic ruler
- Totalizing anemometer (vane or cup) capable of logging wind speed readings at desired intervals
- Multiple 4 foot delineators and snow fencing
- Project-specific liquid supply to be used during pan evaporation test
- Hose and Pump
- Measuring stick or tape measure
- Ballpoint pen and field log

IV. Cautions

A weather station capable of recording temperature, barometric pressure, rainfall, wind speed and direction, and solar radiation MUST BE USED in conjunction with measurements made by this procedure.

V. Health and Safety Considerations

Follow health and safety procedures outlined in the site-specific HASP.

VI. Procedure

Prior to field mobilization, properly inspect all components and hardware associated with your evaporation pan as described in the product instruction manual.

Field Siting Guidelines

For the evaporation pan to perform properly, use these guidelines to select the optimum siting locations. Be sure to take into consideration ease of access for field measurements:

- The evaporation pan should be placed at a location representative of the principal natural agricultural soils and vegetation conditions of the area.
- Under no conditions should the evaporation pan be placed on concrete, asphalt, or crushed rock surfaces.

- The equipment should be placed in an area with level ground and is free of obstructions.

- Obstructions such as shrubs, trees, or buildings should not be closer than four times the height of the tallest component of the pan. The exposure should be free from obstructions that cast shadows over the pan during any part of the day other than brief periods near sunrise and sunset.

- Locate the pan a sufficient distance from spillways, sprinklers, and other bodies of water to minimize chances for water to be blown into the pan by strong winds.

- The site should be surrounded by snow fencing to protect the equipment and prevent animals from drinking the water. At a minimum, the surface of the pan should be covered open-mesh wire screen.

Installation and Operation

The following steps should be used to ensure that the pan evaporation test is functioning properly prior to use.

- Find a level surface, or grade the surface sufficiently to level, for pan support. Keep the pan level above the level of any adjacent surface water. Earth fill should be used around the pan platform to support and anchor it.

- Center the pan on the platform and verify that the platform is level.

- Clean the pan of any sediment, algae and/or oil films which could affect the rate of evaporation and displace water volume.

- Inspect the pan carefully for leaks.

- Secure the 12-inch/30-cm plastic ruler to the side of the pan or stilling tube.

- Fill the evaporation pan with liquid to a height of 200 millimeters (mm) [20 cm]. Prior to filling the pan, note the start time in the field log.

- Place the transducer within the stilling tube. Set up and initialize the transducer following product specific procedures. Ensure that the transducer is collecting measurements by moving the transducer to generate a response; the transducer will be connected to the field computer during verification. Following verification of function, secure the transducer and/or cable to the stilling tube using zip ties.

- Set up and calibrate anemometer following product specific procedures. Insure that anemometer is positioned such that it is measuring wind speed within 12 inches of the top of the evaporation pan.

- Insure that weather station is installed and operational. See ARCADIS *Standard Operation Procedure: Weather Station Installation and Operation* for further details.

Routine inspection and maintenance of the evaporation pan and associated gauges will be conducted as required by the project schedule and/or weather conditions. The following steps should be used to ensure proper data collection.

- Perform a visual inspection of the evaporation pan and associated gauges and note any damage that may be affecting operation. If damage is found, contact the PM for guidance.

- Check the evaporation pan for debris. If debris was removed, note the date and time of removal and type of debris.

- Check the evaporation pan for leaks. If any leaks are found, notify the Project Manager.

- Verify that the evaporation pan remains level.

- If liquid levels within the pan drop below 150 mm [15 cm], add enough liquid to retain the 200 mm [20 cm] water level height. Use a measuring stick or tape measure with at least 1 mm accuracy to verify water height. Allow water level to calm before taking the final measurement.

- Verify that the pressure transducer and anemometer are recording measurements at the desired/selected intervals.

The pan should be emptied by siphoning or dipping the water out. Under no circumstance should the pan be lifted and emptied if any significant amount of liquid remains in the pan. During months when freezing is likely, empty, clean, and store the pan. The pan should be stored indoors. If left outside, it should be turned upside down and secured to the ground.

Data Recording and Management

Measurements from the pressure transducer will be recorded at intervals and for a duration as determined by the Project Manager, consistent with the requirements of the investigation. Data will be downloaded from the transducer and loaded to a computer using the data collection and management associated software. Periodic data downloading may be instituted depending on the length of the test. Thermometer data will be recorded by trained personnel during inspection/maintenance events and recorded in field logs.

Electronic records (downloaded transducer data) will be transmitted to the ARCADIS PM as directed by the PM. The employee responsible for data download will retain electronic copies of all downloaded data on the field computer. Field log records will be transmitted to the ARCADIS PM at the end of field event unless otherwise directed by the PM. The employee responsible for field notes will retain copies of the field logs. All field data should be recorded in indelible ink.

VII. References

Novalynx Corporation. Model 255-200 Evaporation Pan Instruction Manual (April 2007).

NOAA 2007. National Weather Service Manual 10-1315, Operations and Services: Surface Observing Program (land), NDSPD 10-13 (2007).

ARCADIS

Appendix D

Measurement of Liquid Level in Lagoons/Ponds for Seepage Rate Evaluation

ARCADIS

Infrastructure · Water · Environment · Buildings

Imagine the result

Measurement of Liquid Level in Lagoons/Ponds for Seepage Rate Evaluation

Rev. #: 1.0

Rev Date: October 2, 2013

Approval Signatures

Prepared by: _____ Date: _____
Myles Perkins

Reviewed by: _____ Date: _____
Jonathan Burton, PE_(Technical Expert)

Reviewed by: _____ Date: _____
John DeJong (Editorial Reviewer)

Reviewed by: _____ Date: _____
Steve Hicks, PE (Quality Assurance Reviewer)

Reviewed by: _____ Date: _____
Kevin Freeman (Project Manager)

I. Scope and Application

This Standard Operating Procedure (SOP) provides a step by step guidance for measuring liquid surface level within a lagoon or pond as part of a seepage rate evaluation. The operating procedures described herein include guidelines for equipment installation, operation and measurement collection.

II. Personnel Qualifications

ARCADIS field personnel will have current health and safety training, including site-specific training, as needed. In addition, ARCADIS field personnel will be versed in the relevant SOPs and possess the skills and experience necessary to successfully complete the desired fieldwork. The project Health and Safety Plan (HASP) and other documents will identify any other training requirements, such as site specific training or access control requirements.

III. Equipment List

- Health and Safety equipment, as required in the site HASP
- 4-inch diameter thin-wall PVC perforated (2-hole, 5/8-inch hole diameter) drain pipe with bell end
- Drain pipe end cap
- Vertical staff (stream) gauge, metal or fiberglass, graduated in feet, 10^{ths}, and 100^{ths}
- Bubble level
- ¾-inch or 1-inch PVC pipe
- Gauged (vented) pressure transducer with temperature sensing/recording capabilities (LevelTROLL 700 or equivalent)
- Field computer with transducer data collection and management associated software installed
- T-post and/or anchors
- Nylon cable (“Zip”) ties
- Measuring stick or tape measure

- Hand tools
- Wooden or metal survey stakes
- Ballpoint pen and field log

IV. Cautions

This procedure is ONLY for lagoons/ponds that are NOT synthetically-lined; actions required as part of this procedure will damage and/or perforate synthetic liners.

This test requires that the lagoon/pond be isolated from inflow and outflow for the duration of performance. Prior to beginning the test, ensure that the owner/operator of the lagoon/pond has a clear understanding that the lagoon/pond will not (through hard controls) accept or drain liquid for the duration of the test. **Confirm that the owner/operator has made alternate arrangements for any flow typically, anticipated, and/or possibly to be received by the pond/lagoon prior to beginning this test**.

Analysis of lagoon/pond seepage rate(s) requires concurrent measurement of weather and evaporation rates. **Use of this procedure alone will not provide information sufficient to determine a lagoon/pond seepage rate**.

V. Health and Safety Considerations

Follow health and safety procedures outlined in the site-specific HASP.

VI. Procedure

Prior to field mobilization, properly inspect all components and hardware associated with your water level measurement equipment. As structures are lagoon/pond specific, they will need to be constructed in the field prior to placement. Lengths of pipe required will be determined prior to mobilization.

Equipment Installation

For the water level measurement equipment to perform properly, use these steps for equipment preparation. Be sure to take into consideration ease of access for equipment installation and field measurements:

1. Mobilize to pond or lagoon.

2. Isolate the lagoon or pond by blocking, closing, disconnecting, or otherwise eliminating, inflow and outflow sources. Verify with owner/operator that isolation is complete and that lagoon/pond will remain isolated for the duration of the test.

3. Site the location of the perforated transducer stilling pipe (the "pipe"). Wind speed and direction can have an impact on liquid level due to fetch and wave action. The pipe should be placed somewhere along a line through the middle of the lagoon that is perpendicular to the prevailing wind direction; it is expected that the amount of fetch in the lagoon will increase across the lagoon in the direction of the prevailing winds.

4. Install the pipe. Secure the end cap to the "bottom" end (the end of the pipe intended to be in contact with the lagoon/pond bottom) of the perforated pipe using glue or screws. The pipe will extend from above the pond shore line to the base of the pond. Slide the perforated pipe along the embankment into the lagoon/pond, adding and securing additional pipe lengths as necessary, until contact is made with the lagoon/pond bottom. If survey data is available for the lagoon, this distance to bottom can be calculated. If no survey data is available, contact with the bottom of the lagoon/pond will be based on empirical information (resistance to insertion). Allow time for the pipe to fill with liquid as it is being introduced into the lagoon; this will prevent the pipe from floating. Record the length of the pipe. Secure the pipe to the lagoon/pond embankment using stakes, anchors, and/or T-Posts as necessary.

5. Install the staff gauge. The gauge is to be located within the in the current liquid volume of the lagoon/pond, adjacent to the pipe. Determine a location along the pipe (using the measuring stick) such that at least 2 feet of liquid head is present; the gauge will be placed at that point. Drive the T-Post into the embankment and vertically level the post using a bubble level. Attach the staff gauge to the T-Post using zip ties; the bottom of the staff gauge should be in contact with the embankment.

6. Arrange for a survey of the staff gauge height so that readings from the gauge can be correlated to surface elevation.

7. Place the transducer within the perforated pipe. A small-diameter (¾ or 1-inch) PVC pipe may be required to convey the transducer to depth (within 1-foot of the bottom of the pipe based on recorded pipe length) within perforated pipe. Set up and initialize the transducer following product specific procedures. Ensure that the transducer is collecting readings by moving the transducer to generate a response; the transducer will be connected to the field computer during verification. Following verification of function, secure the transducer cable to the pipe using zip ties. Provide protection to the transducer cable using stakes, anchors, or other means as necessary to ensure that the cable remains securely attached to the stilling pipe.

8. After allowing the liquid surface to still, measure the liquid level on the staff gauge and record the result. Concurrently, record the liquid level as measured by the transducer. This measurement will serve as the correlation/baseline measurement, providing the relationship between liquid surface elevation and transducer readings.

Data Recording and Management

Measurements from the pressure transducer will be recorded at intervals and for a duration as determined by the Project Manager, consistent with the requirements of the investigation. Data will be downloaded from the transducer and loaded to a computer using the data collection and management associated software. Periodic data downloading may be instituted depending on the length of the test. Staff gauge readings will be collected by trained personnel during field events and recorded in field logs.

Field log records will be transmitted to the ARCADIS PM at the end of field events unless otherwise directed by the PM. The employee responsible for field notes will retain copies of the field logs. All field data should be recorded in indelible ink.

VII. References

Ham, J. M., 2002. Uncertainty Analysis of the Water Balance Techniques for Measuring Seepage from Animal Waste Lagoons. J. Environ. Q. (2002) 31:1370-1379.

NOAA 2007. National Weather Service Manual 10-1315, Operations and Services: Surface Observing Program (land), NDSPD 10-13 (2007).

USBR, 2001. Water Measurement Manual: A Water Resources Technical Publication, revised reprint, 2001. United States Department of the Interior Bureau of Reclamation, Water Resources Research Laboratory.

ARCADIS

Appendix E

Field Forms

Lagoon Staff Gauge Measurement Log

Lagoon Name:_____

Date	Time	Staff Gauge Reading